§ 14. Impact of L-H Transition on Edge MHD Stability

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The H-mode with edge transport barrier (ETB) and ITB modes with internal transport barrier (ITB) are typical improved confinement regimes observed in not only tokamaks but also helical systems. Magneto-hydrodynamic (MHD) stability of these plasmas with transport barriers is an important issue for toroidal plasma confinement. MHD stability of a tokamak H-mode plasma seems to be determined by ballooning and/or peeling modes. Recently, on LHD, the L-H transition was observed in the so-called inward-shifted configuration[1]. This configuration is favorable for particle confinement but unfavorable for MHD stability, in particular, against interchange modes because of wide magnetic hill region. MHD stability in the hill region is crucial for LHD plasmas. The ETB formation by the transition in the magnetic hill region provides a good opportunity to study edge MHD stability.

Figure 1 shows time evolutions of the line averaged electron density $<n_e>$, the averaged toroidal beta $<\beta_t>$ measured with a diamagnetic loop and the Hα-light across the L-H transition. As seen from this figure, $<n_e>$ and $<\beta_t>$ linearly increase in a short interval less than ~10 ms just after the transition. Then, $<\beta_t>$ suddenly saturates by the excitation of ELMs of which amplitude is enhanced by about 30% having high repetition rate up to 500 Hz, although $<n_e>$ is gradually rising due to constant gas puffing. In contrast to the tokamak mode, magnetic fluctuations dominated by edge MHD modes are strongly enhanced at the transition, as shown in Fig.2. The dominant mode is m=2/n=3 (m, n: poloidal and toroidal mode number), of which relevant rational surface is located in the ergodic layer just outside the predicted last closed flux surface (LCFS) of the vacuum field and in the vicinity of ETB. In this shot m=2/n=2 mode is also enhanced but suppressed by the first ELM. The Hα-light spikes by ELMs correlate well with m=2/n=3 MHD mode bursts. The most likely candidate of this edge MHD mode is resistive interchange mode, because the rational surface is in the magnetic hill region but in the stable zone against ideal interchange mode due to high magnetic shear. Note that incoherent magnetic fluctuations up to 100 kHz are also enhanced at the transition. Large radial electric shear and high edge electron temperature in the edge region might suppress the resistive interchange activities.

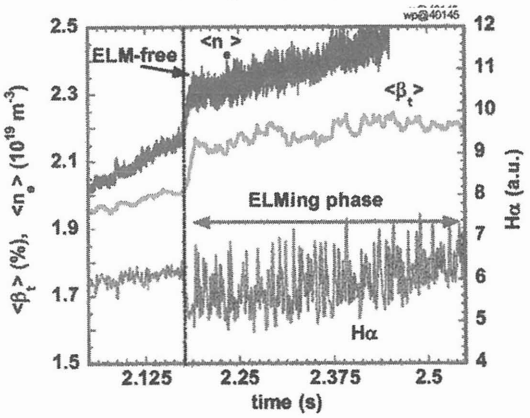

Fig.1 Time evolution of $<\beta_t>$, $<n_e>$ and Hα-light in an H-mode discharge that ELMs clearly affect the stored energy or $<\beta_t>$, where $<n_e>$ is continuously increased by gas puffing.

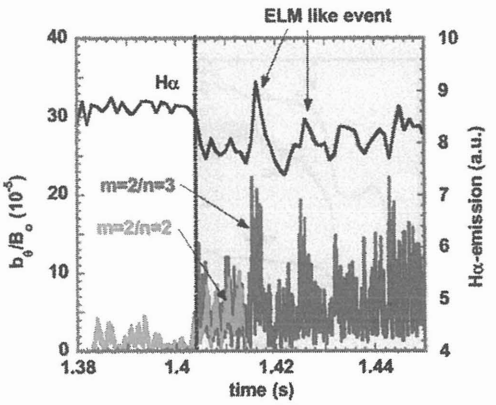

Fig.2 Time evolution of the amplitude of m=2/n=3 and m=2/n=2 magnetic fluctuations together with Hα-light.

References

[1] K. Toi et al., Proc. 19th IAEA Fusion Energy Conf., Lyon, 2002, paper No. EX/S-32, and K. Toi et al., 30th EPS Plasma Phys. Nucl. Fusion Res., St. Petersburg, 2003, paper No. O-2.3A